

# Developing Tools for Estimating Hazard Exposures Related to Public Health

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# Major Objective

- Develop tools for assessing linkages between environmental hazards, human exposures and chronic diseases
  - Improve the characterization of the exposure scenario
    - Major challenges are the temporal latency and spatial distance between exposure and disease
  - Create a tool to proactively identify potential environmental public health problems.
  - Facilitate focused hypothesis testing.

# Focus of this Project

Evaluate the possibility of moving beyond land use as a proxy for potential pesticide exposure to a geographically-based hazard score estimate.

RESULT

Screening Level

Agricultural Pesticide Hazard Score Estimate

# Primary Data Sources

	Health Outcome and Demographic Information		Crop Information		Agricultural Chemical Use Information	Agricultural Chemical Properties		Groundwater Susceptibility
<b>Primary Agency/ Source</b>	US Census	WI Cancer Registry	National Agricultural Statistics Service	Wisconsin Department of Agriculture	Wisconsin Agricultural Statistics Service Pesticide Use Report	US EPA "Chemicals Evaluated for Carcinogenic Potential	Toxnet– <a href="http://toxnet.nlm.nih.gov">http://toxnet.nlm.nih.gov</a>	Wisconsin Department of Natural Resources
<b>Parameter of Interest</b>	Population at risk	Childhood cancer cases	Crop acreage	Crop land data layer	Acres planted, percent applied, annual application rate (lbs/acre)	Toxicity – relative weight of evidence suggesting potential for carcinogenicity	Persistence – propensity of chemical to be found and persist in groundwater	Groundwater Susceptibility Model (GCSM)- models ease to which water travels from land surface to groundwater
<b>Years used in model</b>	2000 Census	1994-2002	1996	2004	1996	July 19, 2004	Variable based on available data	1987
<b>Historical data years available</b>		1976-2004		2002-2003		N/A	Variable based on available data	None
<b>Updates</b>	Every 10 years (2010)	Annually		2005	2004 (available October, 2006)	Updated as pesticides are registered and reviewed	Variable based on available data	None planned
<b>Level of Resolution</b>	County, census tract, block group	address level	county	30 * 30 km grid	Statewide Estimate	N/A	N/A	1900m* 1900m

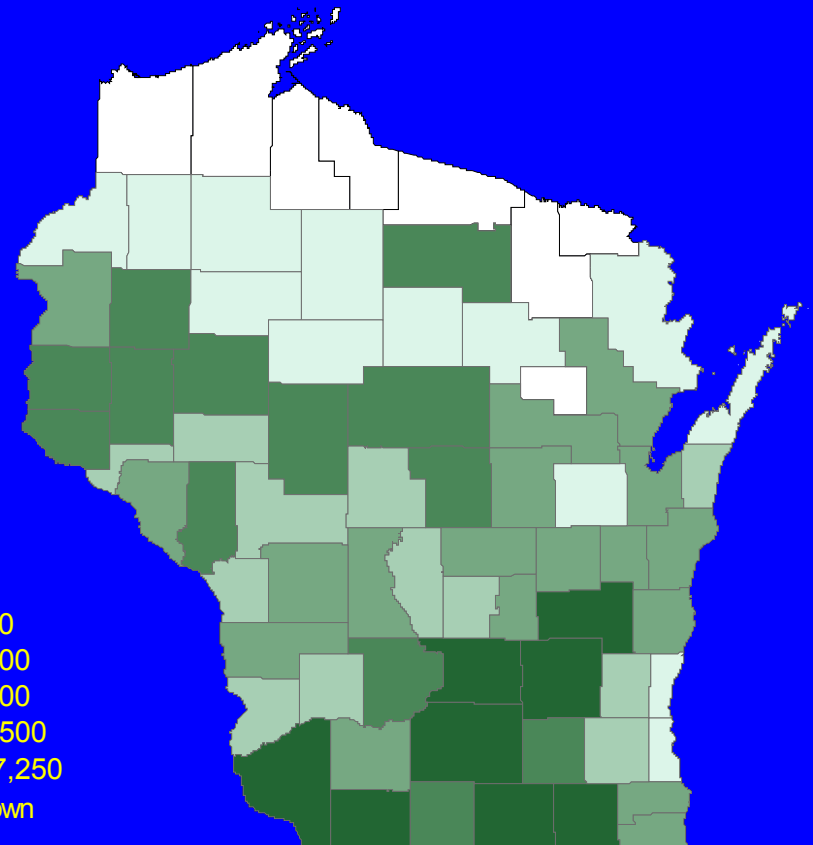
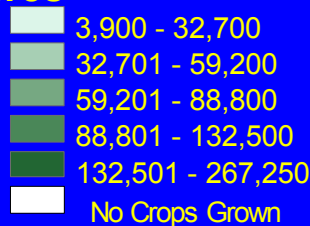
# Hazard Location

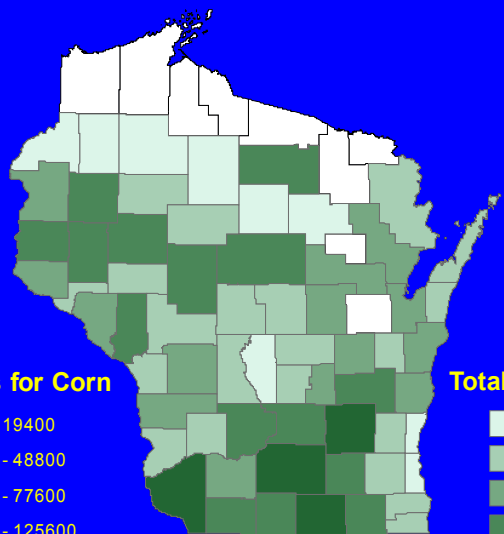
Have acreage information for top 6 crops that comprise 99.2% of all crops grown in the state

Corn	(76.05%)
Soybeans	(17.90%)
Sweet Corn (processing)	(2.22%)
Potatoes	(1.50%)
Snap Beans (processing)	(1.29%)
Green Peas (processing)	(1.03%)

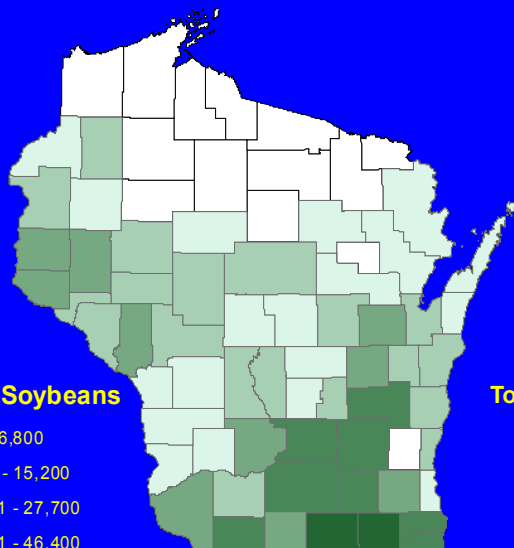
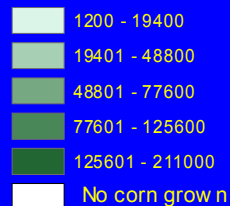
Cranberries  
Sweet Corn (fresh market)  
Apples  
Cabbage (fresh market)  
Cucumbers (processing)  
Carrots  
Cabbage (processing)  
Tart Cherries  
Onions  
Strawberries

## Acres

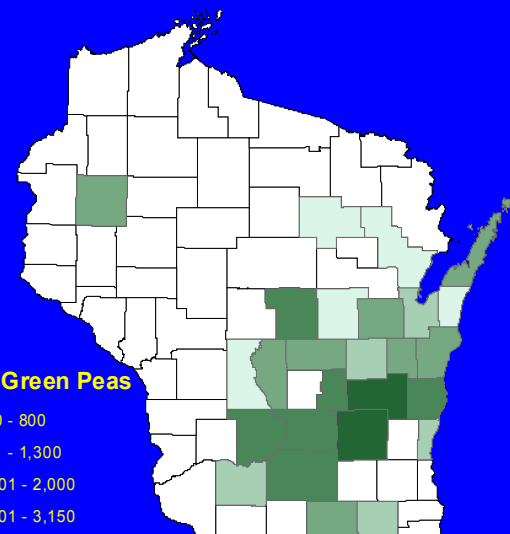
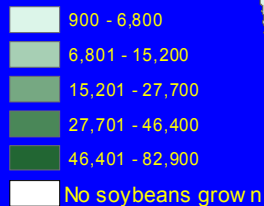




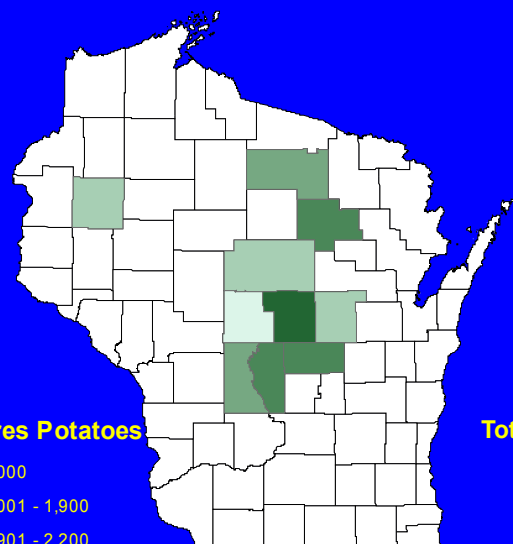
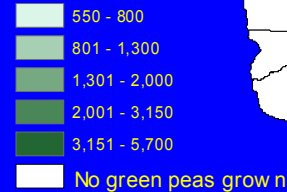
**Total Acres for Corn**



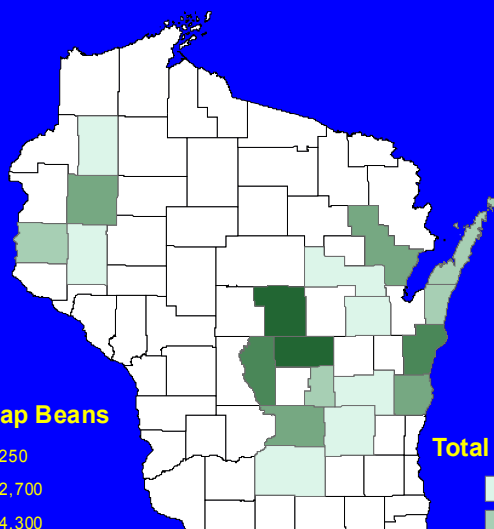
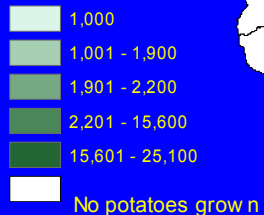
**Total Acres Soybeans**



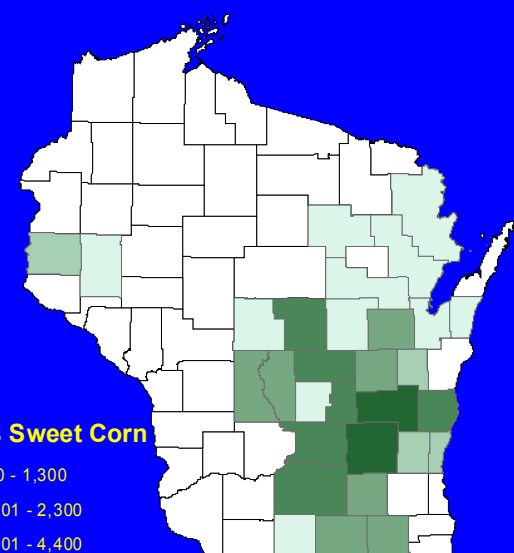
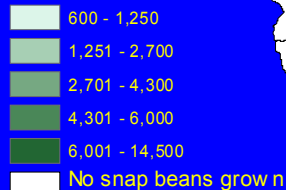
**Total Acres Green Peas**



**Total Acres Potatoes**



**Total Acres Snap Beans**



**Total Acres Sweet Corn**



# Calculate County-level Estimates of Pesticide Usage

Total acres planted  
(from NASS 1996 stats)

X

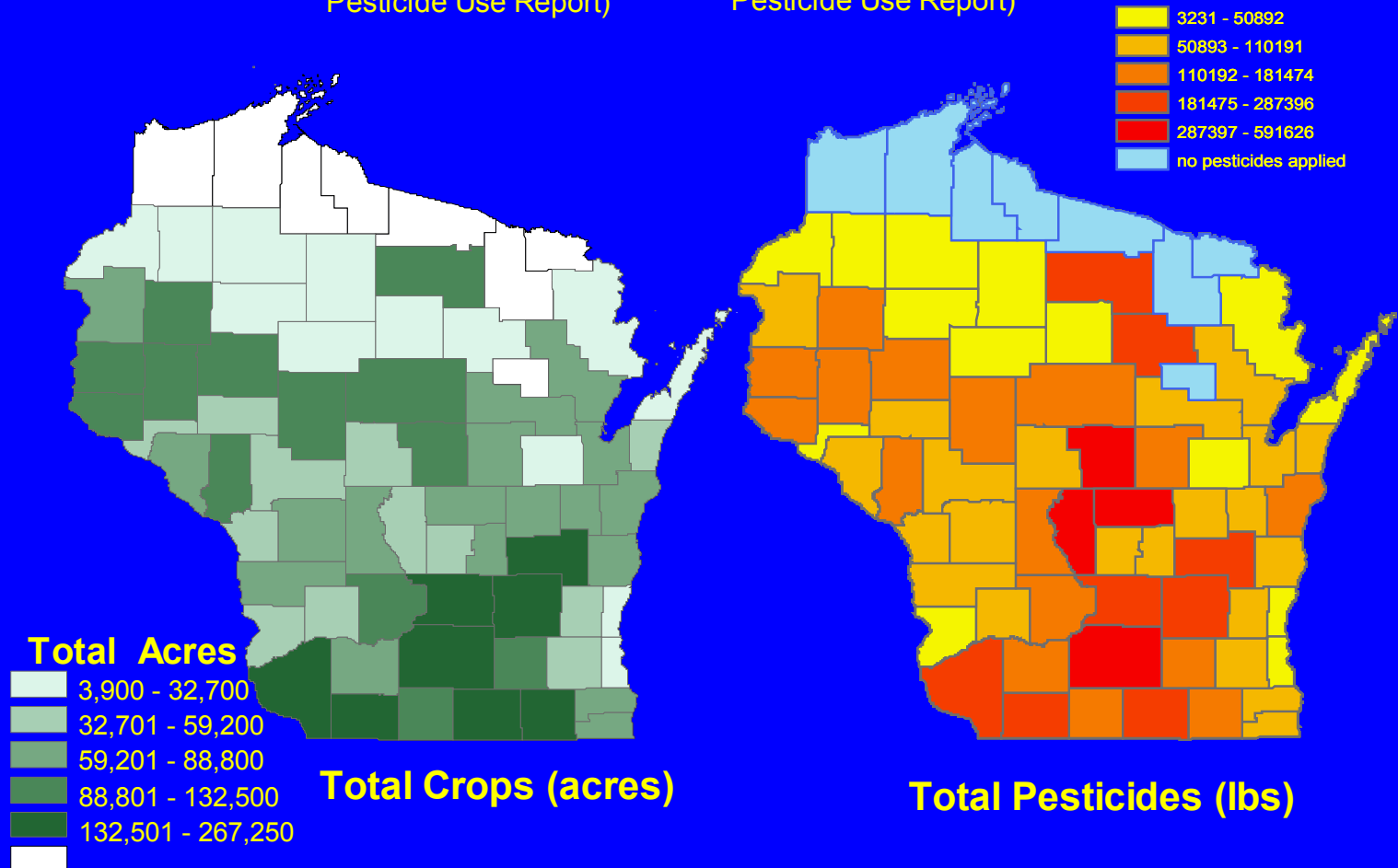
% of area receiving pesticide application  
(from 1996 WASS Pesticide Use Report)

X

average number of applications per year  
(from 1996 WASS Pesticide Use Report)

X

application rate (lbs/acre)  
(from 1996 WASS Pesticide Use Report)

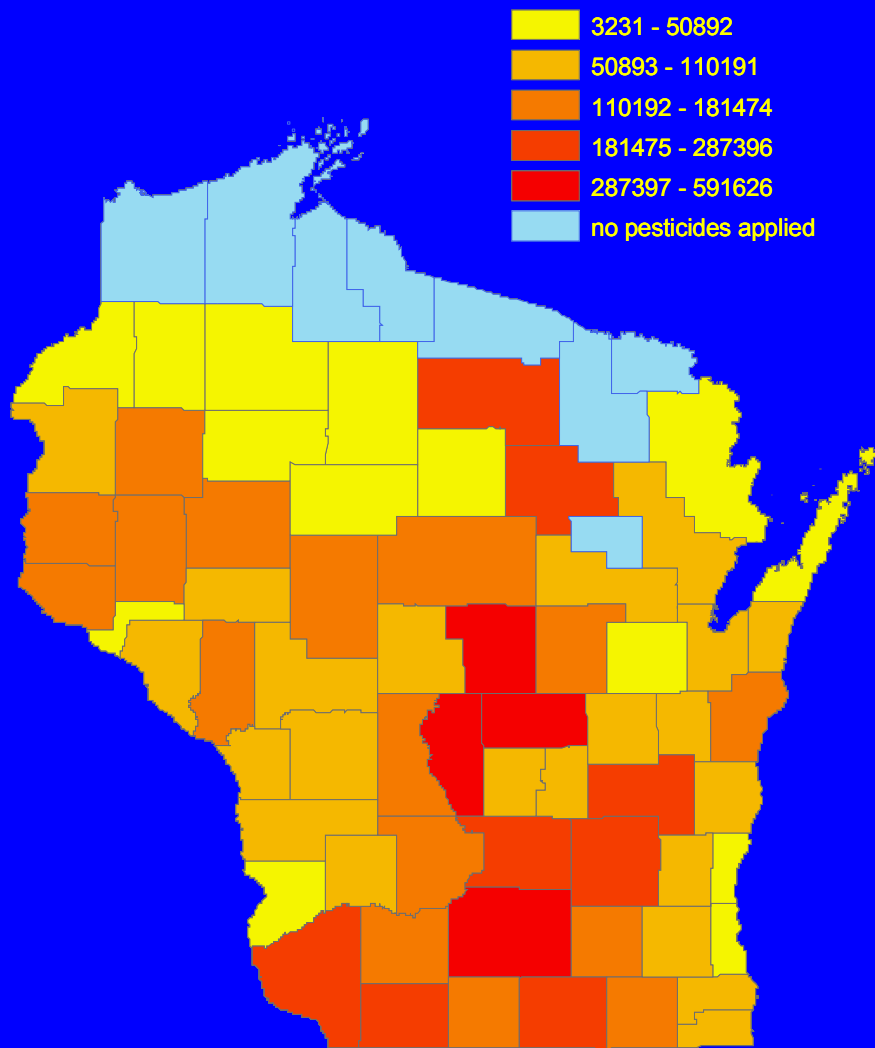


# Hazard Definition

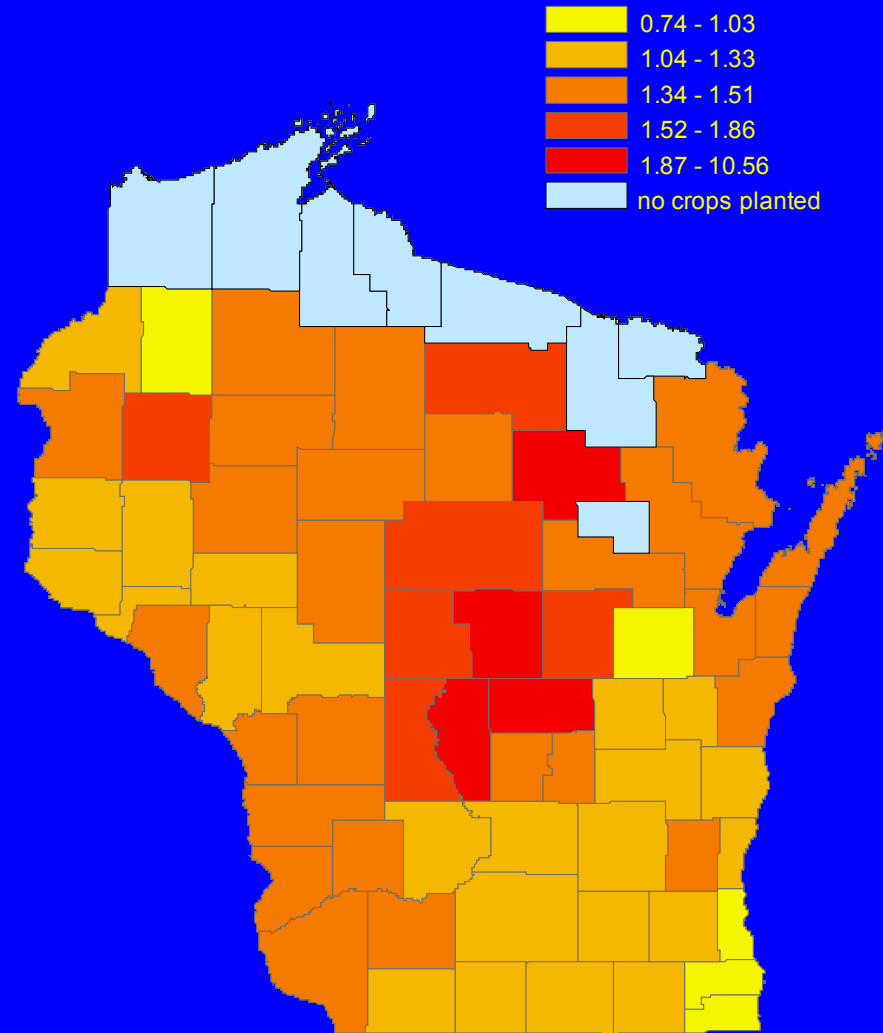
- Examine list of pesticides reported to WASS in 1996 Pesticide Use Report
- Narrow list of pesticides
  - Environmental Protection Agency – chemicals evaluated for carcinogenic potential
    - 103 Pesticides  $\longrightarrow$  34 Pesticides
    - Classified as possible, probable, likely, or suggestive evidence of carcinogenicity
    - Of the 34 pesticides, in 1996, **19 were applied to the six crops of interest**
  - Environmental Protection Agency & California Prop 65
    - Toxicity/Carcinogenicity/Persistence
    - Identify the agricultural chemicals of interest



Pesticide	CAS Number	EPA Carcinogenic Classification	Major Crops Pesticide Applied (1996)
<b>Herbicides</b>			
Acetochlor	34256-82-1	Likely to be carcinogenic to humans (high doses), not likely to be carcinogenic to humans (low doses)	corn
Alachlor	15972-60-8	Likely to be carcinogenic to humans (high doses), not likely to be carcinogenic to humans (low doses)	corn, soybeans, sweet corn (fresh market), sweet corn (processing)
Bromoxynil	1689-84-5	Group C- Possible Human Carcinogen	corn
Cyanazine	21725-46-2	Group C- Possible Human Carcinogen	corn, sweet corn (fresh market), sweet corn (processing)
Dimethenamid	87674-68-8	Group C- Possible Human Carcinogen	corn, sweet corn (processing)
Linuron		Group C- Possible Human Carcinogen	potatoes
Metolachlor	51218-45-2	Group C- Possible Human Carcinogen	corn, soybeans, green peas (for processing), snap beans (processing), sweet corn (fresh market), sweet corn (processing)
Pendimethalin	40487-42-1	Group C- Possible Human Carcinogen	corn, soybeans, green peas (processing), sweet corn ( processing)
Simazine	122-34-9	Group C- Possible Human Carcinogen	sweet corn for processing
Trifluralin	1582-09-8	Group C-Possible Human	green peas (processing), snap bean (processing)
<b>Insecticides</b>			
Acephate	30560-19-1	Group C- Possible Human Carcinogen	snap beans for processing
Dimethoate	60-51-5	Group C- Possible Human Carcinogen	potatoes, snap beans for processing
<b>Fungicides</b>			
Benomyl	17804-35-2	Group C- Possible Human Carcinogen	snap beans for processing
Chlorothalonil	1897-45-6	Group B2-Probable Human Carcinogen	potatoes
Mancozeb	8018-01-7	Group B2-Probable Human Carcinogen	potatoes
Maneb	12427-38-2	Group B2-Probable Human Carcinogen	potatoes
Thiophanate-methyl	23564-05-8	Likely to be carcinogenic to Humans	snap beans for processing
Triphenyltinhydroxide	76-87-9	Group B2-Probable Human Carcinogen	potatoes
Metam-sodium	137-42-8	Group B2-Probable Human Carcinogen	potatoes



**Total Pesticides (lbs)**



**Estimated Carcinogenic Pesticides  
(lbs per acre)**

**Note: This assumes equal distribution of applications across the state.**

# Building the Model

## Integration of Information into a Screening Level Tool

- Pesticide hazard scores
- Crop scores
- Geographic linkage of crop distribution with crop score
- Weight based on groundwater susceptibility
- Aggregate to population level

# Hazard Ranking Score for Individual Pesticides

$$\begin{array}{ccccc} \text{Application Rate} & \times & \text{Toxicity Score} & \times & \text{Persistence Score} & = & \text{PESTICIDE HAZARD SCORE*} \\ \text{(WASS 1996 PUR)} & & \text{(EPA)} & & \text{(GUS)} & & \end{array}$$

- Application Rate = rate per crop year (lbs/acre)
- Toxicity – based on EPA Classification
- Persistence – based on GUS Score to estimate stability and affinity to drinking water sources

\*adapted from: Gunier, et al (2001); Valcke, et al (2005)

# EPA's- Chemicals Evaluated for Carcinogenic Potential

1996 Classification	Score	1999 Classification	Score	1986 Classification	Score
Known/Likely	10	Carcinogenic to Humans (10)	10	Group A- Human Carcinogen	10
		Likely to be carcinogenic to humans (8)	8	Group B – Probable Human Carcinogen	8
				Group B1	6
				Group B2	5
Cannot be determined	5	Suggestive evidence of carcinogenicity, but not sufficient to assess human carcinogenic potential (6)	6	Group C – Possible Human Carcinogen	4
		Data are inadequate for an assessment of human carcinogenic potential	4	Group D- Not Classifiable as to Human Carcinogenicity	2
Not Likely	0	Not likely to be carcinogenic to humans	0	Group E - Evidence of Non Carcinogenicity to humans.	0

# Toxicity Score - Cancer

Pesticide Information		Toxicity Score	
Pesticides	CAS #	Carcinogenic Potential	Carcinogenic Potential Score
Acephate	30560-19-1	Group C- Possible Human Carcinogen	4
Acetochlor <sup>1</sup>	34256-82-1	Likely to be carcinogenic to humans	8
Alachlor	15972-60-8	Likely to be carcinogen/Not Ilkely at Low Doses	7
Benomyl	17804-35-2	Group C-Possible Human	4
Bromoxynil <sup>1</sup>	1689-84-5	Group C-Possible Human	4
Chlorothalonil	1897-45-6	Group B2- Probable Human Carcinogen	5
Cyanazine	21725-46-2	Group C-Possible Human	4
Dimethenamid <sup>2</sup>	87674-68-8	Group C-Possible Human	4
Dimethoate	60-51-1	Group C-Possible Human	4
Linuron	330-55-2	Group C-Possible Human	4
Mancozeb	8018-01-7	Group B2- Probable Human Carcinogen	5
Maneb	12427-38-2	Group B2- Probable Human Carcinogen	5
Metam-sodium	137-42-8	Group B2- Probable Human Carcinogen	5
Metolachlor	51218-45-2	Group C-Possible Human	4
Pendimethalin	40487-42-1	Group C-Possible Human	4
Piperonyl butoxide	51-03-6	Group C-Possible Human	4
Simazine	122-34-9	Group C-Possible Human	4
Thiophanate-methyl	23564-05-8	Likely to be carcinogenic to humans	8
Triphenyltin hydroxide	76-87-9	Group B2- Probable Human Carcinogen	5

# GUS Score

## Groundwater Ubiquity Score

Includes an estimate of “pesticide movement rating” :

- 1) Soil half-life (days)
- 2) Water Solubility (mg/l)
- 3) Sorption Coefficient (Koc)

$$\text{GUS} = \log_{10}(\text{half-life}) \times [4 - \log_{10}(\text{Koc})]^*$$

Scores:

<1.0 = Very Low

1.0 - 2.0 = low

2.0 - 3.0 = moderate

3.0 - 4.0 = high

> 4.0 = very high

\*source: Vogue PA, Kerle EA, Jenkins JJ. OSU Extension Pesticide Properties Database. 1994. Website: <http://npic.orst.edu/ppdmove.htm> - Retrieved 9/20/2005

# Persistence Score

Pesticide Information		Persistence Score (GUS)				
	CAS #	GUS= Groundwater Ubiquity Score*	Soil Half Life (Days- Persistence)	Water Solubility (mg/L)	Sorption Coefficient (soil Koc)	GUS
Acephate	30560-19-1	Low	3	818000	2	1.76
Acetochlor <sup>1</sup>	34256-82-1	Low	4.3	223	169	1.12
Alachlor	15972-60-8	Moderate	15	240	170	2.08
Benomyl	17804-35-2	Low	67	2	1900	1.32
Bromoxynil <sup>1</sup>	1689-84-5	Low	9	130	300	1.45
Chlorothalonil	1897-45-6	Low	30	0.6	1380	1.27
Cyanazine	21725-46-2	Low	14	170	190	1.97
Dimethenamid <sup>2</sup>	87674-68-8	N/A				1.28
Dimethoate	60-51-1	Moderate	7	39800	20	2.28
Linuron	330-55-2	Moderate	60	75	400	2.49
Mancozeb	8018-01-7	Low	70	6	2000	1.29
Maneb	12427-38-2	Low	70	6	2000	1.29
Metam-sodium	137-42-8	Moderate	7	963000	6	2.72
Metolachlor	51218-45-2	High	90	530	200	3.32
Pendimethalin	40487-42-1	Very Low	90	0.275	5000	0.59
Piperonyl butoxide	51-03-6	Low	14	14.3	600	1.40
Simazine	122-34-9	High	60	6.2	130	3.35
Thiophanate-methyl	23564-05-8	Very Low	10	3.5	1830	0.74
Triphenyltin hydroxide	76-87-9	Very Low	75	1	23000	-0.68

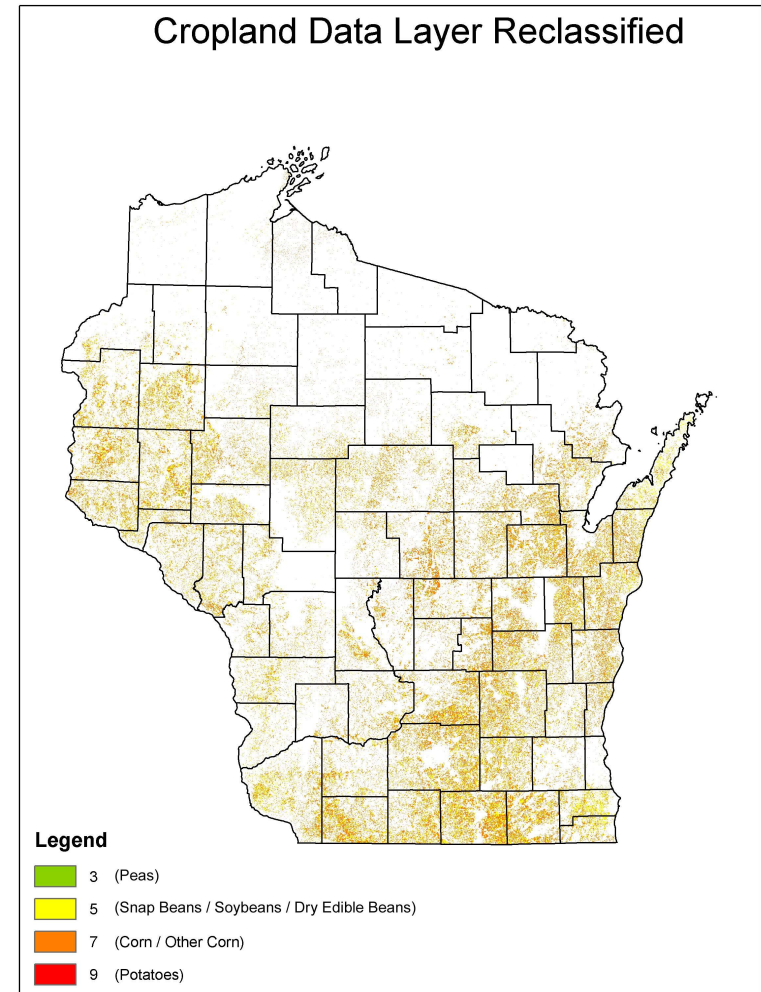


# Crop Hazard Score = Sum of Pesticide Hazard Scores by Crop (e.g. Corn)

CORN				
Pesticides	Statewide Application Rate	Toxicity Score	Persistence Score-	Pesticide Score
Acetochlor <sup>1</sup>	1.80	8	1.12	16.17
Alachlor	1.72	7	2.08	25.06
Bromoxynil <sup>1</sup>	0.30	4	1.45	1.74
Cyanazine	1.35	4	1.97	10.65
Dimethenamid <sup>2</sup>	1.21	4	1.28	6.19
Metolachlor	1.72	4	3.32	22.84
Pendimethalin	1.24	4	0.59	2.92
				Crop Score = 85.57

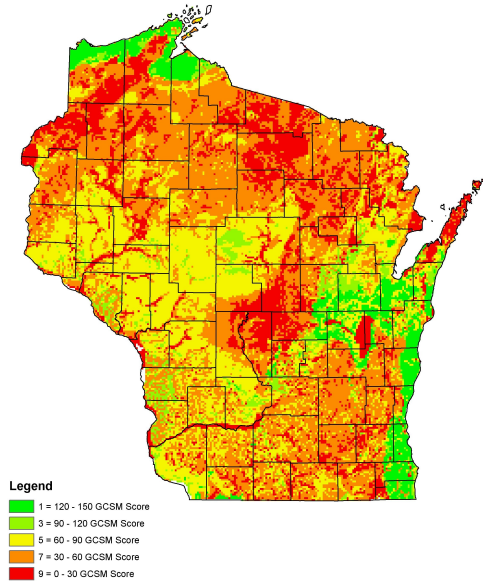
# Crops Scores Applied to Cropland Data Layer

Crop Type	Crop Score
Corn	8.6
Soybeans	5.2
Apples	1.7
Tart Cherries	4.0
Cranberries	7.0
Strawberries	4.0
Cabbage for Fresh Market	0.1
Cabbage Processing	2.4
Carrots	6.1
Green Peas	2.0
Onions	8.8
Potatoes	222.0
Snap Beans for Processing	4.8
Sweet Corn for Fresh Market	5.9
Sweet Corn for Processing	8.1

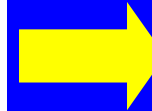
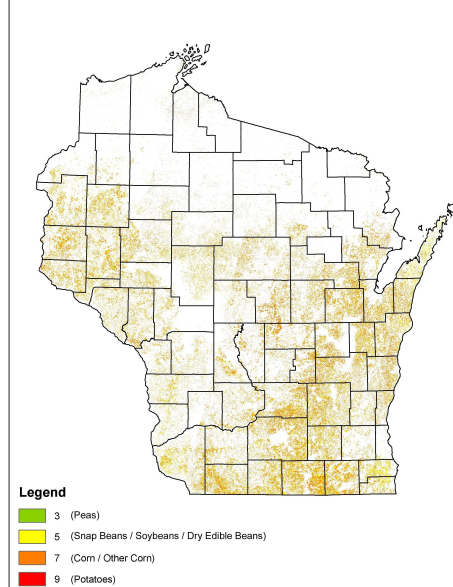


# Integrating Groundwater Susceptibility

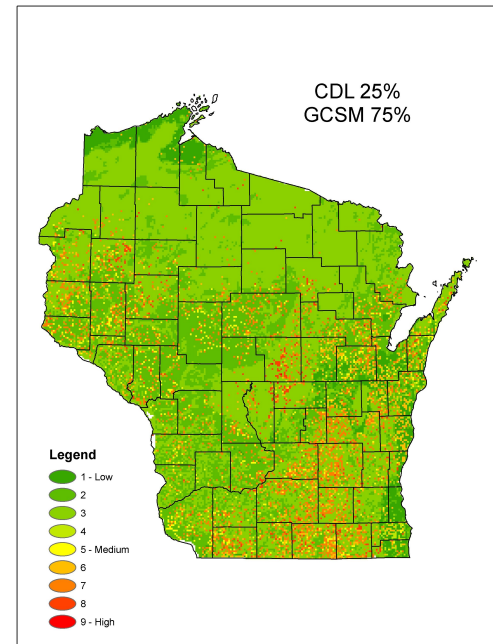
Groundwater Contamination Susceptibility Model



Cropland Data Layer Reclassified



CDL 25%  
GCSM 75%



# Conclusions

- The tool provides:
  - The ability to identify key data gaps and deficiencies
  - The ability to guide policy management decisions and address public concerns proactively
  - A method for putting environmental monitoring data in a public health context
  - The ability to guide hypothesis generation
    - Scores can be linked with health data to
      - » explore ecologic relationships
      - » identify areas for future analytic research
      - » contribute to the building of an environmental exposure profile